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School Science

A Journal of Science Teaching in Secondary Schools.

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A WORD OF CHEER.

The long vacation is over and another school year has begun. That this year may be one of joyful progress to all its readers is the sincere wish of SCHOOL SCIENCE.

Teaching, like all professional work, confers privileges and imposes obligations. One of its privileges is the opportunity to cease from routine work during the summer months; and one of its obligations is to utilize the benefits gained from this vacation.

While these lines are being written a refreshing breeze blows across the dancing waters of Frenchman's Bay, from the rugged hills of Mount Desert Island, off the coast of Maine. Bar Harbor lies at the foot of these hills, but its gay life has no helpful message for the teacher. The green earth, the blue sea and the bluer sky, however, send an eternal message. The earth bids us grow into a life of fruitfulness and symmetry, the sea says, "Let your life be active and harmonious," and the sky tells us to live to the fullest and be poised. You have heard these and other messages from the hill, the river, the lake, the mountain, the bird, the flower. Nature tells us, in so many and such varied ways, that vacation is the time to regain poise of body, activity of mind and consciousness of soul—the season for renewal of the whole being.

The summer vacation is an enviable privilege; but, like many privileges, it has an obligation. The resumption of regular duties should not, however, be accompanied with regrets. There should be no sighs for the past. The present is the time of power. Banish regrets. Let the memories of the summer be filled with joy, power and hope. We have had the privilege, let us, therefore, welcome the obligation. Let the power accumulated during the summer be a constant possession. The throb of Nature's heart

will be just as loud all the year as it was this summer. But, to hear it, we must transmute the peace and beauty of Nature into purpose, industry, hope and poise. The summer's pictures should never be dimmed by winter's labor. Let us, this year, be as firm as the mountain, peaceful as the lake, punctual as the tide, free as the bird, industrious as the bee, poised as the cloud and as beautiful as the flower, recalling ever the harmony and peace of all Nature.

School Science ventures to present to its readers the following obligations, which we, as teachers, may meet if we accept them in unshaken confidence in our accumulated strength:

To remember that some good is in all pupils, and to crave that spiritual insight which shall detect the best; to lead all pupils on to higher attainments; to be patient, composed, forbearing; to be confident in the belief that the truth will ultimately triumph; to scorn error, deceit and all forms of falsehood; to forego sarcasm and injustice; to honor the body; to cherish daily communion with the soul; never to voice the thought of drudgery, routine or performance of duties rightfully another's; to sweeten others' labors with kind words and sincere greetings, and to gladden our own with a silent joy in the dignity of honest labor; to accept our remuneration, large or small, without envy, complaint, discouragement or covetousness, never forgetting that a teacher is a leader into the higher life—not a wage-earner merely; to work each day in unshaken assurance that fullness of peace, power and plenty comes to those who "see the heavenly vision undimmed."

L. C. N.

A PLEA FOR THE STUDY OF EDUCATIONAL PHILOSOPHY ON THE PART OF TEACHERS OF SCIENCE.*

BY N. A. HARVEY.

Head of Science Department, Chicago Normal School.

The results of the teaching of science in high schools have not been altogether satisfactory. There is a feeling, more or less prevalent, that the claims of science have been fully justified.

*Part of the President's Address before the Department of Science Instruction of the National Educational Association read at the Detroit meeting, July 11, 1901.

This finds expression in occasional articles in educational journals, in the recent great gain in the history and language courses over science in high schools and in the refusal of colleges and universities generally to demand science as a requirement for admission.

I cannot but feel that there is some ground for this coolness toward scientific subjects. My own experience would lead me to say that there may be some reason for the position that universities assume. I have recently had occasion to teach two classes a day in physics for three successive years. One was a class of high-school graduates, all of whom had studied physics. The two classes did identical work in the laboratory. For three successive years the tabulated records of the accuracy of data obtained in the laboratory showed that the class which had never before studied physics exceeded the accuracy of the high-school graduates in the proportion of about seven to three. It was a case peculiarly favorable for comparison, and I feel sure that the comparison is indicative of an actual condition in those classes.

The only explanation that I can suggest is that the teaching of the high-school graduates had been conducted under the influence of improper ideals; that the teachers were physicists rather than teachers; that, in other words, they needed to study educational philosophy and to get a rational knowledge of the content of the subject.

If there has been one advance in educational truth better demonstrated than another, it is that, in schools for general education, the knowledge of the facts acquired is not the chief value to be derived from a particular study. There is something more important than that, even in science. Just as the benefit derived from the study of algebra is not to be looked for in the answers to the problems that the student so laboriously solves, and the value of the study of Latin comes not from the knowledge of the historical facts that the pupil learns while reading the Latin language, so the value of the study of science does not depend upon the knowledge that the pupil acquires, but upon the power the student acquires while gaining that knowledge. In physics one set of exercises may be substituted for another without any disadvantage. It makes no difference whether one

class of animals is studied in zoölogy or another, provided other things are equal, and one set of exercises in chemistry may be a full equivalent for another series, yet it would be wrong to give both. In fact, there is recognized a fair degree of equivalency among scientific subjects—something in which they agree among themselves and differ from other subjects in their power to influence the mental habits of students.

In our work in zoölogy we study the structure and life of animals, but if my classes fail to see and to recognize the processes by which a general concept of a group is formed, if they fail to discriminate and compare, if they do not get into the habit of analyzing a specimen before them and of examining it part by part, if they do not learn what is involved in a logical definition, and, more than this, if they do not carry this habit of mind into every other subject in school, I feel that my work has been a failure, no matter how many or what animals they have studied, or how neat their notebooks, or how artistic their drawing.

In the determination of the laws of falling bodies if my classes fail to perceive the continual activity of a constant force by means of the effects, if they do not recognize the uniformity in the apparent diversity, if they do not recognize that here is a law, and how to perceive that law, if all that my students get out of the exercise is a knowledge that $s = \frac{1}{2} g t^2$, or, even worse, if they only learn that, in the laboratory, they can get the result that the text book says they can get, that the book has told the truth, and they have verified the statement, then I am not only a failure as a teacher, but I am a sham and a fraud, and my laboratory is part of a juggler's outfit, the principal purpose of which is to dazzle the pupil and the public. (This is a confession and not an accusation. In classical language, I have been there.)

If, in the determination of copper in copper sulphate, I fail to make my pupils see that the atoms of copper in the final compound which is weighed are the identical atoms with which we began; if the pupil is unable at any stage of the proceeding to point out where the atoms of copper are, then my work is a failure and the educational value of chemistry is either accidental or negative.

The results obtained from the pursuit of scientific subjects

under the influence of such a conception are likely to be very different from what they would be if it were believed that the knowledge of a few animal forms, or a few experiments in physics, were the purpose of scientific study. Of course, it is understood that a professional chemist or an electrician, or an investigator in biology, must know the facts of the particular branch of science that engages his efforts, and must set to work directly and explicitly for the purpose of learning those facts. But that is a phase of work that does not apply to high-school science.

I do not decry the learning of facts, nor would I set up for the pupil this more important but less tangible aim. By a pupil's knowledge of facts the teacher may test, in a measure, the clearness of comprehension, the awakening of power that the pupil obtains. But the teacher must look beyond the mere facts of the subject to the true content that furnishes the reason for its introduction into the curriculum.

The day has gone by when a knowledge of subject matter is considered sufficient preparation for teaching. How much knowledge of mathematics, higher and lower, is necessary to make a person a good teacher of fourth-grade arithmetic? How much knowledge of literature and language would guarantee success in teaching third-grade reading? How many university graduates would undertake a position in the grades of a city school with assurance of success? It is only a tempting of Providence that permits persons too poorly prepared to do grade work to teach in a high school. The application of pedagogical principles is as necessary to high-school work as it is in other grades, and university methods and models are not always capable of universal application.

The teaching of science is still in an inchoate and formative condition. There is no general agreement among teachers of any science, nor between different schools, concerning what shall be taught. Perhaps physics is the science which in high schools is best taught and most clearly defined. But physics in one school means a very different thing from what it does in another school.

The past few years have witnessed many attempts to formulate a course of study in science that shall constitute a point of departure for the teaching in high schools; something that high

schools can teach and that colleges can reasonably expect; something that shall be of value to all students who do not expect to go to college, and yet something that shall be a fair equivalent for the preparatory studies that are now required for entrance into college. This section of the N. E. A. four years ago appointed a committee for the especial purpose of formulating such a course. That committee, after much work, failed to agree, and, so far as accomplishing what it undertook to do, it is as if it had not been. No such course has yet been formulated, and I believe that no such formulated course ever will be generally adopted until it has its basis in the activities of the pupil rather than in the facts of science. A successful and meritorious course in science can never be made by addition nor subtraction nor substitution. No series of exercises can ever be presumed to give constant results. It certainly is not possible at the present time—and may never be possible—to state a course of science in terms of mental activity. But, until that is done, all of our courses in science must be tentative and unpedagogical. Until someone makes a study of the psychology of laboratory science, or shows just the phases of human activity that are most economically cultivated by each scientific subject, our teaching must continue to be more or less empirical and unscientific.

The recent recovery of classical subjects from threatened displacement has followed the recognition that the language of a people is the key to the thoughts of a people, and not merely a quantity of information, valuable or useless as the individual judgment considers it. The revival of history has come about from recognition of the fact that history is an expression of the life of a people, and not merely a catalogue of miscellaneous events. A similar change must occur in the teaching of science. The purpose and reason for science instruction must be sought for in the mind of the pupil, and not in the facts of the subject. For this aspect of the case I plead with all the earnestness of a decided conviction.

The greatest contribution of science to pedagogy has been the "scientific method." The "scientific method" is not a method of teaching, but it is a method of thought. It is a method capable of universal application. This universal method in all of its ramifications, should constitute the basis for all our courses of study in

science, and should determine the method and data of our teaching. I plead for a study of this universal method of thought, and for its exemplification in the things we teach. Then will there be no question concerning what shall be the course of study in science, no hesitation on the part of colleges to accept it as a college-entrance requirement, and no doubt concerning the value of science teaching.

THE AIMS AND PURPOSES OF MODERN WORK IN BIOLOGY.

BY FRANKLIN W. BARROWS.
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The modern epoch in the history of biology dates from the epoch-making work of Darwin and the publication, in 1859, of *The Origin of Species.* For forty years Darwinism has been the chief dominating influence among biologists, stimulating not only fierce and prolonged controversy, but also patient and equally prolonged study and research. For the first decade after the promulgation of the evolution doctrine, the scientific world was arrayed in two hostile camps; Darwin and his followers fought, side by side, through the long campaign, until they compelled the unconditional surrender of every important stronghold of science. And then, the victory won, these comrades in arms began to emphasize their own individual creeds, and to wage controversies among themselves, which have developed for the last quarter century, until, today, the term "Evolution" stands for a heterogeneous mass of doctrine, in which we may discern at least three distinct schools, and a bewildering number of different shades of opinion. Thus, at the end of forty years, we are able to trace considerable progress in the evolution of an evolution theory. The *fact* of organic evolution is, practically, unquestioned. The lively controversies of today are concerned with the *methods* of evolution and imply a deeper and broader knowledge of the problems of life than was possible before Darwin's day.

While we recognize the important directive influence of Darwinism upon his own time and ours, we must not forget the bril-

liant achievements of many other workers who in earlier days laid the foundations of physiology, embryology, and nearly every other department of biologic work of anatomy.

But the number of these pioneers was small. The great majority of naturalists were content to spend their time in naming and classifying, according to rude and artificial methods, all sorts of living things; they overlooked more important questions while they sought out appropriate names for species and genera, and entertained the most absurd notions and fancies concerning life and its activities. This was about the state of affairs in America when Louis Agassiz was elected to the first professorship of natural history in Harvard College, in 1848, and began his career which was destined to transform the ideas and practices of every naturalist within reach of his influence. While Agassiz steadfastly opposed the advance of Darwinism, he maintained his position at the head of American zoölogists, because he was a born leader, a fascinating teacher, and an enthusiastic investigator. The leading American zoölogists of the present were trained by Agassiz, and reverently profess their debt to his personal influence; but his bias against the "phantom," as he called it, which Darwin and other naturalists were chasing, did not prevent his own students from becoming apostles of Darwinism and quoting his own brilliant discoveries in embryology against himself.

The stimulus to scientific activity which followed the launching of the doctrine of evolution, gave every biologist new work and more of it. The active workers had to verify the facts and observations which Darwin had been patiently and quietly accumulating for thirty years. Theorists had to subject the whole body of scientific knowledge to rigid re-examination, to revise their creeds, to affirm and re-affirm the foundations of biology. Every worker, from the specimen hunter to the professor and philosopher, found his occupation growing in importance from year to year. Scientific pursuits acquired a fascination and a popularity hitherto unknown. The army of scientists received recruits,—often very raw recruits they were,—at the expense of those institutions which still leaned toward the scholastic ideals of the Middle Ages. Colleges and universities shook off their conservatism and awoke to recognition of the new learning. Sci-

entific thought ran in new channels and expressed itself in a new and strange dialect.

It is the purpose of this paper to trace briefly a few of the many lines along which biology has developed, during this truly wonderful epoch, to state a few of the present aims and objects and to estimate the spirit of modern workers in this science.

The present status of biology would be quite impossible without the existence of laboratories. We owe the development of this idea mainly to Germany, where the model biological department, as much as fifty years ago, included at least five kinds of laboratories,—for botany, zoölogy, physiology, anatomy and pathology, respectively,—the latter science first receiving official recognition in 1849, when Professor Virchow was elected to the first professorship of pathological anatomy in the world. Nearly all of the biological laboratories deserving the name have arisen within the last twenty-five years; in America the best laboratories are all less than fifteen years old. But even this brief period has been sufficient for the development of the most exact laboratory methods and for the springing up of a new school of "laboratory biologists,"—men whose sole environment is the laboratory, and who believe that the questions of biology are mostly capable of being resolved into laboratory problems and solved by the aid of apparatus. The inevitable reaction against such narrowness has begun. Mere "section cutters" are falling somewhat into disrepute. An American physiologist* says:

We need to realize in our modern laboratories that turning the crank of a microtome in and of itself has no more educational value, possibly not so much, as turning the crank of a grindstone. In fact, our theories of *laboratory research* and even of *laboratory instruction* in the brief period in which these have come into prominence have gone far astray. In drifting away from all considerations of human good and even common sense, our modern laboratory work is in the same danger of becoming an end in itself that sunk the old classification into a worse than imbecile waste of time.

Another leader† imagines Aristotle visiting us and asking the question: "Is not the biological laboratory which leaves out the

*Dr. C. F. Hodge, Clark University Decennial Volume, p. 113.
†Dr. W. K. Brooks, Foundation of Zoölogy, p. 41.

ocean and the mountains and meadows a monstrous absurdity?"

In view of these criticisms it is very gratifying to know that within recent years we have established a number of laboratories which conform much more satisfactorily to the rational type suggested in Aristotle's question. Our seaside and lakeside laboratories and our agricultural experiment stations and fish hatcheries are contrived to bring the investigator into the closest possible intimacy with the lives and surroundings of the plants and animals which he observes and subjects to experiment. The marine biological station at Naples was at once the pioneer and the model in work of this kind, and its successful establishment was followed by the opening of one or more marine laboratories in nearly every civilized land, followed somewhat tardily by inland laboratories on the shores of lakes and rivers, beginning with Switzerland. In America the seaside work begun so auspiciously on the island of Penikese by Louis Agassiz, was resumed after an interim of several years by the founding of the Marine Biological Laboratory at Woods Hall in 1888. It is no exaggeration to say that since this time the Woods Hall laboratory has been the biological center of America, although five or six newer laboratories have sprung up at different points on our coasts. The number of fresh water biological stations in America is considerable, many of our state universities taking the lead in this movement. In all such laboratories the work of teaching is subordinated to the more important functions of investigation and experiment. The U. S. Fish Commission and the Fish and Game Commissions of many of the states maintain similar stations where the purely economic aspects of biology receive the chief attention.

Not alone in the biological stations, but in the Agricultural Experiment Stations the laboratory men are learning to go out of doors for their facts. Our government is much more generous to these agricultural institutes than to the fish stations and the results have more than justified the expense. Indeed it may be said with truth that the American government leads the world in the practical study of applied biology, especially in economic entomology. Our agricultural colleges and stations were, most of them, established as the result of the acts of Congress known

as the Morrill Act of 1862 and the Hatch Act of 1887. We now have fifty-six experiment stations in all, employing 678 officers. During the last ten years the number of these stations has increased about 20 per cent, while the cost of maintenance and the number of men employed has increased 70 per cent.* The results reached during the last quarter century have been of inestimable value. In England they have a very expressive term for the scientific study of soils and crops; they call it "manuring with brains." In order that we may know whose brains have been manuring the farms of the United States, we are told that in 1898 out of a total of 669 officers on the staffs of our experiment stations, 305,—or more than 45 per cent,—gave instruction in colleges. Thus, our government has indirectly interested itself in getting the "laboratory naturalists" out of doors. The general effect upon the biologist of such laboratories as we have been describing is well expressed by Professor Forbes, the state biologist of Illinois, who says: "It is, in fact, the biological station, wisely and liberally managed, which is to restore to us what is best in the naturalist of the old school, united to what is best in the laboratory student of the new." He might have added that the work of these institutions is giving character to the teaching in all our colleges and many of our secondary schools,—is, in fact, setting the pace of biology in this country.

This out-of-door activity, led by those investigators, who revolt from the notion that all the world can be sliced up and seen through the microscope, has given rise to a new branch of biology, which they have christened ecology, and which deals with the relations of living things to each other and the surrounding world; their modifications and adaptations in response to their environment. It is a branch of biology which takes us to the homes and haunts of life, back to nature herself. It is offered to the student as the newest novelty in biology and is highly recommended by doctors of philosophy as an antidote for the more sedentary pursuits of the laboratory.

The fresh-water biologists have also evolved a new sub-science, limnology, which is not yet defined in the dictionaries, and which applies to the study of lakes and their inhabitants.

*Year Book of the Department of Agriculture, 1899, pp. 513-548.

One of the departments of biology which lends itself most readily to laboratory methods is embryology. Although it had arrived at the dignity of a science before the beginning of this century, it was natural that it should receive a new and powerful impetus from the Darwinian movement, and it has, in fact, absorbed a large majority of the energies of investigators for the last twenty years, during which time the science of comparative embryology,—the comparison of embryonic development in different groups of animals,—has grown up. As the development of one group of animals after another has been carefully investigated and described, the comparative embryologist has been forced, in his search for the essential differences in development, to look farther and farther back. Thus a constantly increasing interest has attached to the earliest stages of growth in the egg, and even to the fertilization of the egg by the male element.

(*To be continued.*)

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY.*

BY GEORGE W. MYERS.

It is trite to say that the educative value of any subject is to be measured, neither by the number of facts to be memorized, nor by the utility or grandeur of its ideas, so much as by the amount of original thought it stimulates in the learner. School education seems to have three pretty sharply-marked stages, viz.: the period of the memorizing of both the thoughts and statements of authors; the period of memorized thought and original statement, and the period of originality of both thought and statement. Strange how many teachers, while theoretically commending the superiority of the third period, remain, even today, in their practice, quite within the second!

*For the convenience of those who may desire to use these experiments (there are forty-four of them) in their classes, they may be obtained in pamphlet form from "The School Science Press," Ravenswood, Chicago, at 25 cents a copy, and $2.50 a dozen.

Again, the educative worth of what is taught consists quite as much in the questions it raises as in those it settles. Pupils should be taught to put questions to Nature as well as to require Nature to answer them. The education involved in the asking of pertinent questions is at least as important as that involved in their answers, because the formulating of the question suggests the analysis on which the answer depends. In fact, all study is haphazard which is not directed, from the outset, toward answering a definite question, which should be as clear in the pupil's as in the teacher's mind. One of the reasons why our teaching is not more highly educative is because teachers do not lead pupils to formulate their own questions out of the facts and phenomena which they *observe* but do not *see*.

The child's mind is naturally disposed to ask questions; but the training of children does not always accentuate the natural bent. Perhaps there is no other respect in which the learned differ so widely from the ignorant as in the tendency to question what is observed. The ignorant man seldom, if ever, questions what he sees; while the truly-educated man always does. How many thousands had witnessed the vibrations of Galileo's swinging chandelier, or the falling of unsupported objects, without ever thinking of the reasons for these phenomena? It took the seer to ask the simple question, "Why is this so?" And the answer was soon forthcoming. It is believed that the exercises which follow derive no small part of their value from the training they give the pupil, who solves them in the raising of questions.

It may be said that the purposes of these exercises are: To lead the pupil to harken to the questions which nature's most obvious phenomena arouse in every thoughtful mind; to suggest to him such elementary methods of attacking these questions as will enable him to appreciate the value of both careful study and what the race has done for him, and to give him a fuller realization of the road, over which the race has traveled on its search for the truth, than can be obtained from a study of text-books. A single truth wrought out, from start to finish, by the pupil himself, is worth more to him than the reading of pages of fine writing about what others have done.

If correctness of principle, rather than accuracy of results, is

sound pedagogical doctrine for the elementary and secondary teacher, it is thought these exercises may even lay claim to soundness in this particular.

Finally, it is hoped that others may find such exercises as these may suggest as stimulating, teachable and educative, in actual class-room work, as the writer has found them; and that the common notion that expensive apparatus and elaborate library facilities, on the one hand, or pure text-book study, on the other, are not the only alternatives open to the teacher of elementary astronomy who believes in the efficacy of scientific methods of imparting truth in the class-room.

The first six experiments are intended to give the beginner in astronomical measurement an idea of the way he may use his hands and a few sticks and strings and other ordinary auxiliaries to secure better and more accurate results than can be obtained by mere guesses at the magnitudes he must now deal with. Their value consists chiefly in clearing away the confusion which confronts the student when he first comes to the necessity of estimating and measuring angular magnitudes, and in clarifying his views as to the nature of the problems in measurement which are demanded in astronomy. These exercises will enable the novice to convert his *guesses* into *estimates,* and lead him to feel the need of the still higher accuracy which is attainable through the construction of such auxiliary apparati as follow. The measurements involved in these exercises are to be executed upon familiar objects, thereby eliminating the element of mystery, which too often troubles the beginning student when he first has to do with celestial objects and more refined and complex instruments. The next two exercises seek to establish, experimentally, by measurements on familiar objects, certain fundamental laws, on which later and more difficult exercises depend. In short, the first seven exercises are merely intended to orient the student with reference to the problems which follow.

Experiment I.

To find the length of one's pace.

(a.) Stake out a square acre, on level ground, and, pacing its perimeter and diagonals two or three times, determine the length of your pace.

(b.) Measure with the tape, and stake out, on a 5 per cent or 10 per cent grade, a line of 100 feet or 200 feet, and step it not less than five times both upwards and downwards. Determine the length of pace both upwards and downwards, and compare the lengths with each other and with the lengths for level ground.

Experiment II.

To find the angle of the fingers and hand held at arm's length.

(a.) Extending your arm horizontally in front of your face, measure the distance from your eye to the palm of your hand, the arm being fully extended and the hand being bent at a right angle

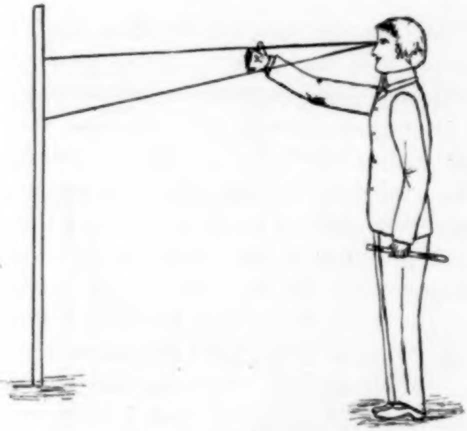


Fig. 1.

to the axis of the arm. Measure now the breadth of the individual fingers, their combined breadth across the joints just beyond the knuckle, and the breadth of the palm across the knuck-

les. Construct on paper isosceles triangles having the hand and separate finger breadths as bases, and all having the distance from the eye to the middle of the palm as altitude. Measure the vertical angles of these triangles with a protractor, and keep a record of their values for your own hand and arm.

(b.) Set a flagpole or stick behind your hand, and at a measured distance from the eye, and measure the spaces just covered by your separate fingers and palm on the pole. Using these as bases, construct to any convenient scale isosceles triangles as before. Obtain the angles with a protractor, or trigonometrically as in (a).

[NOTE: Experiments I. and II. will furnish convenient standards for obtaining estimates of lengths of lines, distances to remote objects, and sizes of angles which will be considerably better than mere guesses.]

EXPERIMENT III.

To erect an approximate perpendicular to a given line from a given point within the line.

(a.) Let the observer stand on the given line (usually marked by two stakes stuck in the ground) at the given point, and face the direction whence the perpendicular is to proceed. Let him then extend both arms horizontally, the one toward the right and the other toward the left, holding the thumbs upward for sights. Holding the neck straight, in continuation with the spinal column, let him now turn his head, first toward the right and then toward the left, sighting in the right thumb on the right stake, then the left thumb on the left stake. This done, he will turn his head squarely to the front, then carry both arms horizontally to the front at the same time, until the palms are together, with the thumbs extended upward. Sighting over the thumbs, he now indicates to an assistant where to stick a stake in the line of his eye and thumbs, or notes where this line touches some more or less distant object. This point, which must be marked, and the point over which the observer is standing, will determine the required perpendicular. This method is used by engineers in rough preliminary surveys.

(b.) Test the accuracy of the right angle just constructed, by the 3-4-5 or 6-8-10 method of turning right corners, used by carpenters and builders.

(c.) Test also by means of the principle of equal oblique lines.

(d.) Repeat method (a) until some degree of accuracy and certainty is secured.

Experiment IV.

To find the slant of the sun's rays to the plane of the horizon.

(a.) Holding a stick vertically, measure its height and the length of its shadow, and plot, to any scale, the measures on two

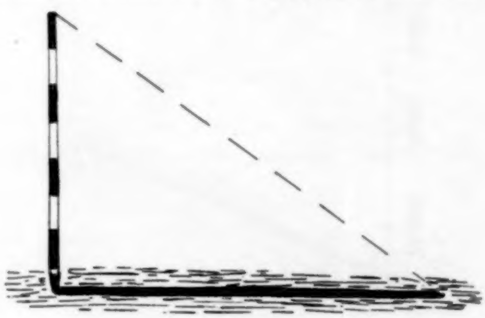


Fig. 2.

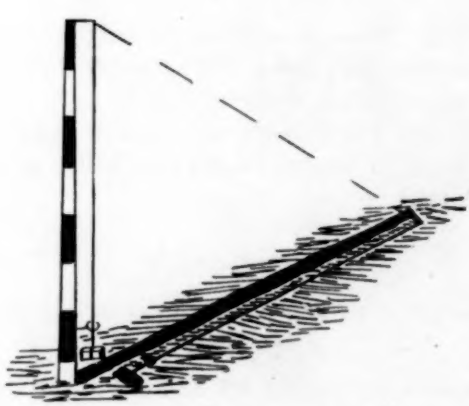


Fig. 3.

lines drawn perpendicularly to each other. Connect the ends, and measure with protractor the angle opposite the line representing the height of the stick.

(b) With the aid of a plumb-line held at the top of the stake and passing through a narrow ring near the bottom the stake may be held more nearly vertically. The plumb-line may consist of a brickbat tied to a string.

(c.) Perform the experiment with the plumb-line supplied with a bead (a piece of cork) sliding with gentle friction up and

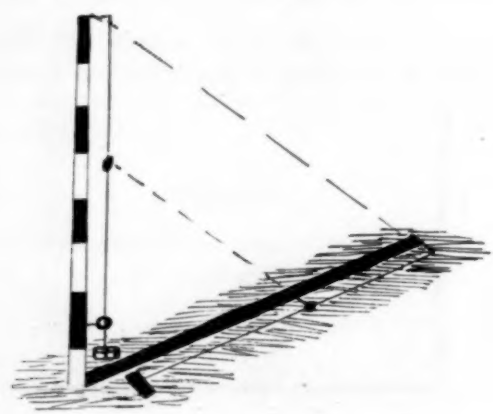


Fig. 4.

down the string. Measure and use the height of bead and distance of its shadow from point directly under the bob (brickbat) as height of stick and length of its shadow were used above.

[NOTE: These experiments will furnish more accurate values for the angle, if treated trigonometrically, as may be done by older students.]

EXPERIMENT V.

To find the height of a tree, building, or other object by the length of its shadow.

(a.) Measure the lengths AE and CD of the shadows of the building and of the stick. Then if AB=h, we have

$$h : CF = AE : CD, \text{ or, } h = \frac{AE}{CD} CF.$$

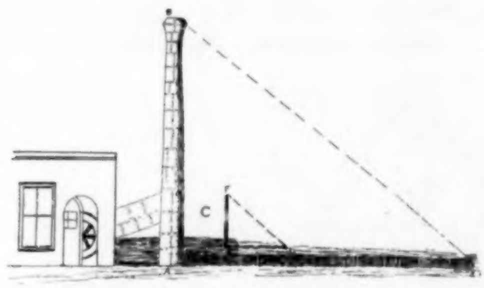


Fig. 5.

Experiment VI.

To find the horizontal, or oblique, dimensions of an inaccessible object, distances being known, and conversely.

(a.) Place yourself approximately (by guess) in the perpendicular at the mid-point of the dimension (DE) to be measured, and, setting a stake at your station (A), get behind it and line in with the ends of the dimension to be found at distances 10 feet, 20 feet, or 100 feet from this station two other stakes

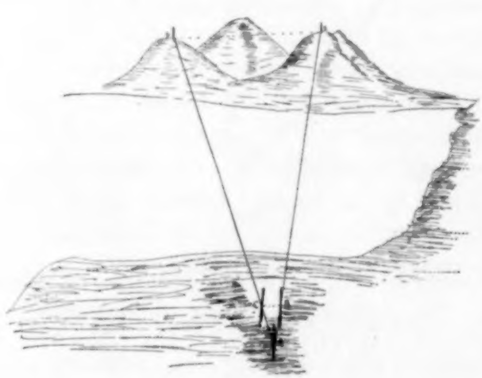


Fig 6.

(C and B), and measure the distance, BC, between these two stakes. The distance from your station to the ends of the line DE being known, the proportion of (a) Experiment V. furnishes the solution; thus h:BC=AB:AD.

[REMARK: If the dimension is unknown, the distances are thus obtainable.]

(b.) This experiment may also be executed with an extemporized plane table, consisting of a flat-topped camera tripod, to the top of which a light drawing-board is screwed, the alidade (ab., Fig. 7), being made of a foot rule carrying two vertical needles for sights. The leveling up may be done with a 25-cent level to be had of any hardware dealer, or with a home-made level consisting of a small glass vial nearly filled with alcohol, the bottle being countersunk in a block of wood.

(c.) For an oblique dimension, by sighting along the top of the board (B) the plane of this board may be brought into the plane of the line to be measured and the line of sight to the middle of the board by adjusting the lengths, or positions, of the tripod legs. The sighting with the alidade and measuring are then carried out as in (b).

Fig 7.

(To be continued.)

AN IMPROVED FORM OF KUEHNE'S ARTIFICIAL EYE.

By E. P. Lyon.

Assistant Professor of Physiology, Rush Medical College, Chicago.

The apparatus devised by Professor Kühne, of Heidelberg has long been one of the best means of demonstrating the refraction phenomena of the eye. However, the instrument as constructed by foreign makers is so clumsy and expensive as to preclude both its use by the individual student and, in many cases, its presence as part of the scientific equipment of schools and colleges. The number of phenomena which it illustrates is also quite limited.

Desiring to introduce the instrument at Rush Medical College, Dr. Zoethout and myself have devised several improvements, and with the assistance of the Geneva Optical Company have put into use in our laboratory a modification of Kühne's apparatus which leaves little to be desired. It is well adapted for individual experimentation in students' hands and makes clear both the refraction phenomena of the normal eye and also various abnormal conditions and the proper corrections for them.

The basis of the instrument consists of a rectangular box about ten inches long, five inches high and four inches wide. The box is open at the top. One end and one side are of glass. At the other end is the cornea represented by a convex glass. A series of diaphragms which slip in back of the cornea represent the iris and various sizes of the pupil. Lenses are provided which can be suspended from the top of the box behind the diaphragm and represent the crystalline lens. There is a lens for near and one for far objects. The retina is represented by a ground glass plate, which also hangs from the edges of the box and may be adjusted to any position. All the optical parts are made in spectacle or "trial case" sizes, thus reducing the expense very considerably.

When the "eye" is to be used, the box is filled with distilled water to which a few drops of 1 per cent eosin solution are added. The fluorescence thus given to the water enables one to trace

the rays of light, to see the bending of the rays at each refracting surface and to follow them as a beautiful cone to a focal point. The water in front of the crystalline lens represents the aqueous humor, and that behind the vitreous, both of these in the normal eye having the same refractive index as water.

The artificial eye is best used in a partially darkened room. The object viewed is represented by a lamp, preferably an incandescent electric or Welsbach. A cross or other figure placed before it is an advantage. When two objects are needed at one time, one near, the other farther away, a candle represents the second. For experiments in which the object is moved, candles or small kerosense lamps are more satisfactory than the Welsbach.

The following phenomena were demonstrated by each student in my laboratory:

1. *Images.* The inverted, real image on the retina. The comparative size of image when object is near and far. Comparative movement of object and image.

2. *Accommodation.* The change in the crystalline lens necessary to make a sharp image when the object is brought nearer. The "near" and "far" points of accommodation. Blurring of image when object is too near. The blurred image of a distant object when the eye is accommodated for a near one, and *vice versa.*

3. *Function of the Iris: Spherical Aberration.* The comparative sharpness and brightness of images of near or far objects when using large or small diaphragms, or no diaphragm at all. A ring diaphragm is provided by which the light may be shut out from the center of the lens and allowed to pass through the outer portion. The change of focus thus effected and "circles of diffusion" can be demonstrated.

4. *Refraction.* The bending of the rays at the cornea and at the lens. The convergence of the rays to a focus and divergence after passing it. The comparative refractive power of the two lenses.

5. *Scheiner's Experiment.* A special diaphragm with two

holes is provided for this experiment, and all details of it can be illustrated.

6. *Far Sight.* The eye is shortened by moving the retina forward. A clear image of a distant object can be obtained, but not of a near one. The eye is provided with a lens holder in front of the cornea, and proper lenses ("trial-case lenses") to correct this and other anomalies of refraction are supplied.

7. *Near Sight* is illustrated and corrected in similar manner.

8. *Astigmatism.* A special asymmetrical "cornea" is provided, which may be substituted for the "normal cornea." The cone of rays as seen from the side will now be found to come to a different focus from that seen from above. This is beautifully demonstrated. To focus the upright of a cross the "retina" must be placed (according to the axis of astigmatism) either behind or in front of the point at which the horizontal bar is focused. Assuming that either position of the "retina" is the normal, lenses are provided for the corresponding corrections; and the lens holder is graduated for the determination of the angle at which the axis of the cylinder must be placed. Astigmatism combined with myopia or hypermetropia may be illustrated and corrected.

9. *Vision without Lens.* The condition when the lens, as in case of cataract, has been removed. Improvement of vision by a very small diaphragm (pin-hole image) and by use of lenses.

10. *Purkinje-Sanson Images.* The images formed by reflection from the surfaces of the lens and cornea. The effect on these of accommodation.

11. *The Function of the Cornea.* It may be shown that the cornea alone can furnish an image by placing the "retina" far back. A further illustration is made as follows: A glass plate with a rubber washer is held against the mounting of the "cornea" in front; and the space between it and the "cornea" is filled with water. The "cornea" is thus thrown out of function. The image is blurred, the focus being back of the "retina." This illustrates the imperfection of vision under water.

By using two "eyes" side by side, many of the phenomena of binocular vision can be demonstrated. The retina can be marked

oft in squares with pencil or India ink, and the theory of identical points can be illustrated. Double vision from crossed eyes is easily made clear to the student. These experiments were omitted in my laboratory only from lack of time.

Doubtless other experiments could be devised. I can only add that my students have been so much pleased with the "eyes" that many of them have put in extra time studying the phenomena which they illustrate.

A NEW MACHINE FOR ILLUSTRATING THE LAWS OF UNIFORMLY ACCELERATED MOTION.

BY W. H. HAWKES.

Instructor in Physics, Ann Arbor (Mich.) High School.

It is hardly necessary to recount to teachers of physics the difficulties encountered in an attempt to illustrate and demonstrate the laws of uniformly accelerated motion, and to do it so that the results will be at all quantitative in character. These difficulties are too apparent by experience to need discussion. We shall not take time nor space to review the many devices and methods, already too well known by their aggravating futility, employed to overcome these difficulties, but rather shall present a new and effective device for solving this perplexing problem and demonstrating the laws of falling bodies with a degree of accuracy that compares favorably with that of other standard quantitative problems in experimental physics.

The value of the results obtained by any method in solving a physical problem depends in a large measure upon the extent to which we are able to eliminate sources of error. In the problem of uniformly accelerated motion the two great sources of error with which the experimenter must contend are friction of the moving parts and the personal equation. Friction may be reduced by the use of very delicate bearings to a quantity that will be hardly apparent in results. The personal equation is necessarily large, and is not so easily disposed of, even in cases where the experimenter has trained senses and good judgment; but the

most trained ear or eye is not sensitive to sound or sight beyond the sixteenth of a second; hence the space traversed by a body (which is considerable at its greatest velocity) during this time is enough to render the observed value doubtful and uncertain. The use of the inclined plane involves the errors arising from the observer's estimates of the coincidence of two dissimilar sense perceptions; either the click of the clock and the crack of the rolling ball, as it strikes the ruler held across the plane, or the position of the moving body at the instant the click of the clock is heard. In either case the demand upon the untrained perceptions of the high-school student is too great, and the consequent errors of observation render the results of little value. The old form of Atwood's machine involves nearly all the sources of error manifest in the inclined plane, so that only approximate results are obtained from its use, while the large amount of time consumed in securing sufficient data is in itself a fatal objection to its employment in laboratory classes enrolling many students. For these reasons this useful and instructive experiment has, in many laboratories, been supplanted by problems of lower importance, because they require less experimental skill and furnish more accurate results.

An attempt has been made in the instrument here presented and herein described to secure results that will be not only independent of any error in judgment and sense perception, but will also render it possible to obtain a continuous record of distances traversed during corresponding intervals of time.

This instrument may be called a self-registering Atwood's machine. Its essential parts (Fig. 1) are a marking device, *M*, controlled by a pendulum, *P*; a wheel, *W*, hung on delicate bearings (jewel) carrying upon its rim a belt of tissue paper ribbon, *T*, upon which the record is to be made, and to which are attached the counterpoised masses, *C C*, and overweight, *O*.

The pendulum is first adjusted by leveling screws in the base of the instrument so that the needle point at its lowest end stands when at rest exactly in the center of the mercury globule, *H*, through which it passes on closing the circuit, *P C*, controlling the recorder, *M*.

After the recorder has been adjusted, a switch, *S*, connects

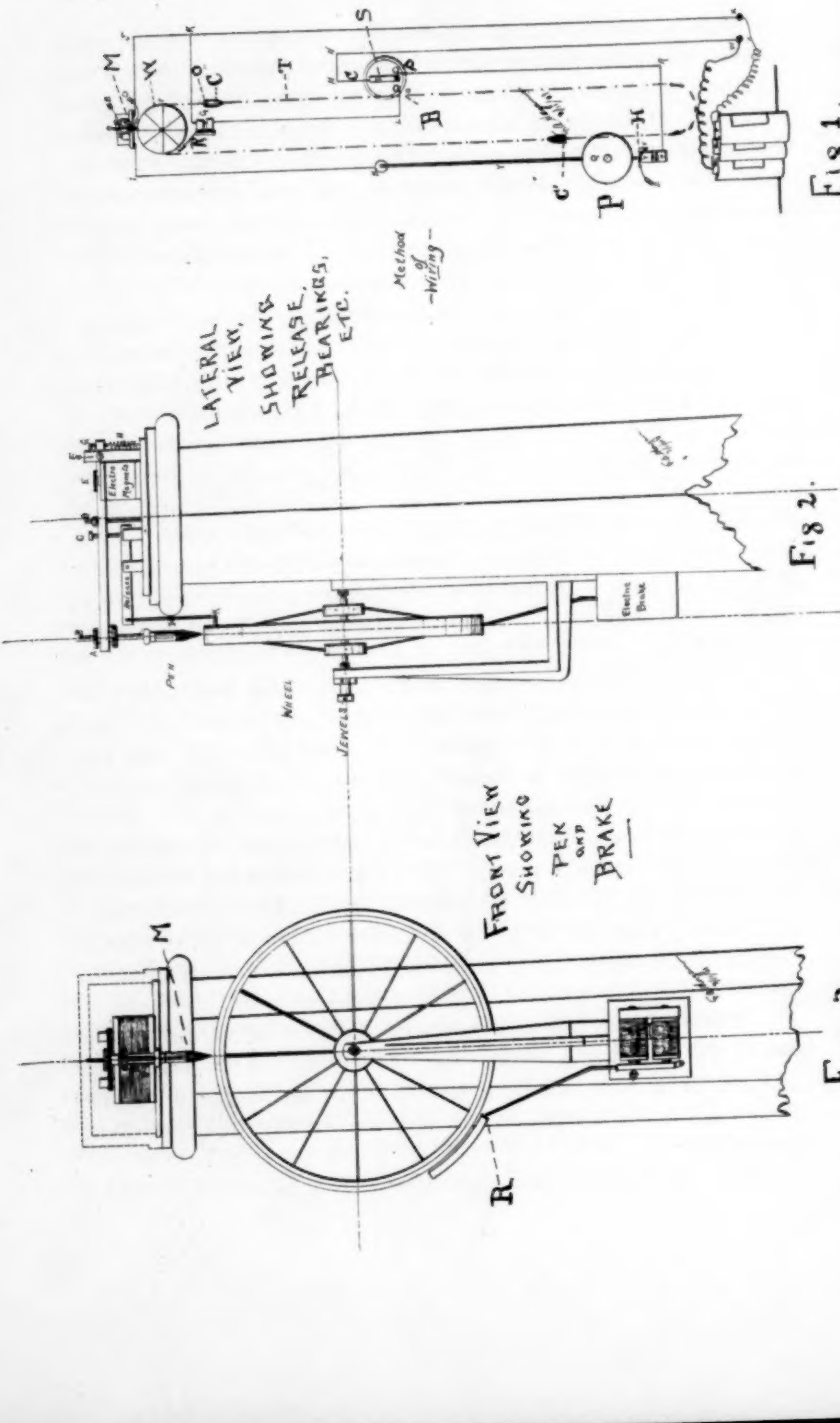
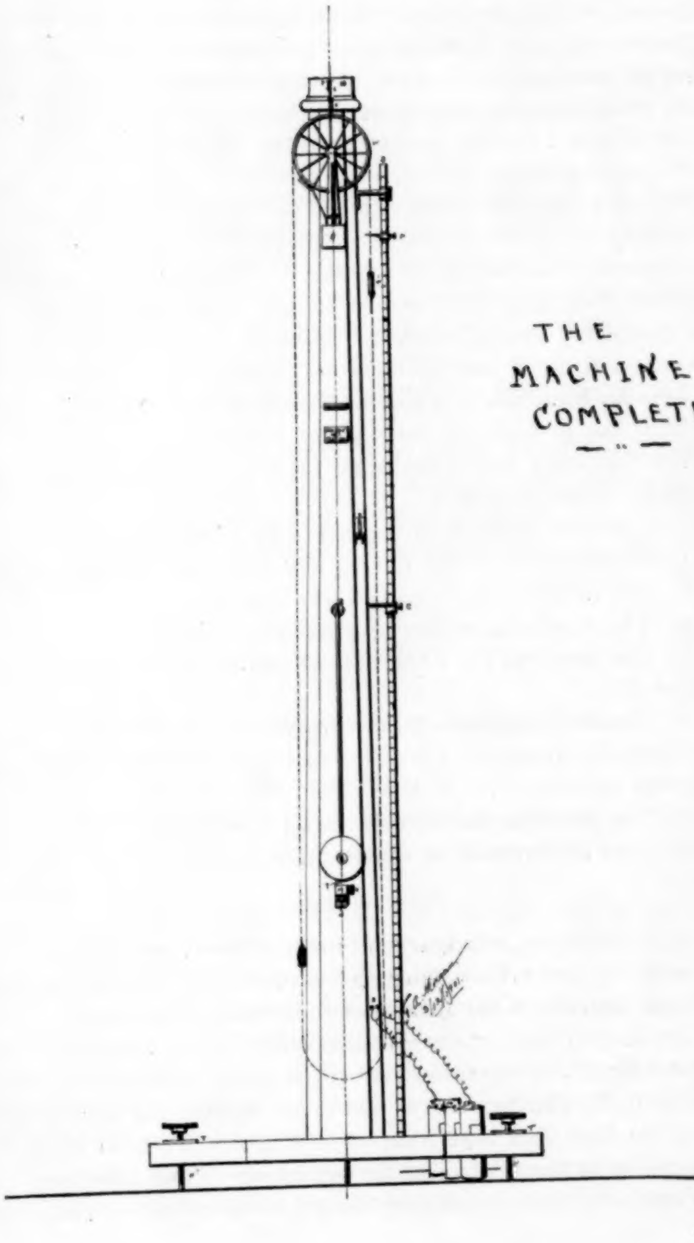


Fig 1.

Fig 2.

Fig 3.



THE
MACHINE
COMPLETE

the battery to the pendulum circuit, when turned to the point *P*. At the first passage of the pendulum through its lowest point, the wheel is automatically released (release shown in Fig. 2), and at the same instant the point at which the motion begins is made on the ribbon. As the motion continues the spaces passed over by the moving system of weights is recorded by the pen, and when the falling weight has nearly reached its lowest point, the operator, by turning the switch to the point marked *B*, throws the current into a circuit which energizes a brake, *R*, (shown in Fig. 3), which simultaneously stops the motion of the wheel and the pen, *M*. The completed record is easily detached from the machine for measurement, or it may be measured directly as it hangs on the machine by means of a graduated column and a sliding pointer reaching out in front of the marked ribbon.

The following facts concerning the laws of falling bodies may be shown from these data:

1. The total distance at the end of each time unit.
2. The distance fallen during any time unit during the fall.
3. The velocity at the end of any time unit.
4. The acceleration due to gravity.
5. The law that the total distance varies as the square of the time of fall.
6. The law that the distance traversed by the body during each time unit varies as $A\ S\ (2T—1)$ times the distance fallen the first time unit.
7. The law that the velocity varies with the time.
8. That acceleration is a constant quantity.

FIRST METHOD.

1. The distances as marked on the ribbon represent the total distance the body falls during the respective number of time units, each distance being measured from the first mark.

The second fact, or the distance fallen during each time unit, is found by taking the difference of the above values successively.

Thirdly: The velocity is found by subtracting the distance fallen the first time unit from each of the other total distances. This will give the velocity at the beginning of that time unit.

Fourthly; Subtracting the distance fallen during each time

unit will give the acceleration for each unit. (One-half of the average acceleration is taken as a corrected first value for S, or total distance fallen the first time unit. This must be very exact as all the other values are compared with it).

SECOND METHOD.

By this method any error in measurement of total distances or errors due to inequalities of friction is cut down by the constantly increasing denominator in the formula.

The accelerations thus determined are then used in computing the distances fallen during successive time units and also in computing the velocities as described below.

1. S, or the total distance found, as described in the first method.

2. S′, or distance fallen each second, is found by taking for the first value, $\frac{1}{2}A$, and for each succeeding value adding in succession the accelerations, A, to the first value.

3. Acceleration is determined by substituting the value of S in the formula

$$A = \frac{2S}{T^2}$$

4. The velocity is determined by taking the sum of the accelerations successively.

5. To show that the total distance varies as the square of the times, divide each total distance by the square of the corresponding time; this ought to give a constant quantity if the law is true.

6. To prove that the velocities vary as the time, divide each velocity obtained above by the velocity at the end of the first time unit. Then, since A is constant, V varies as T.

7. To show that acceleration is constant, divide each acceleration by the average acceleration.

8. To show the ratio of the distances traversed by the falling body during the successive units of time, divide the distance traversed during each unit by that traversed the first unit.

To make this still more clear, a set of data is worked out in full below. These values are the results as actually taken from

a single ribbon. The values of the different quantities are derived as described in the foregoing directions:

S=total distance.

S′=distance fallen during each time unit.

A=acceleration.

V=velocity.

The average of $\frac{1}{2}$ *A* is taken for the value of the first *S*.

TIME	TOTAL DISTANCE	DISTANCE EACH SECOND	VELOCITY AT END OF TIME	ACCELERATION
Units	$S = \frac{1}{2} a T^2$	$S^1 = \frac{1}{2} a (2T-1)$	$V = AT$	$A =$ Constant
1	3.58 cm.	3.57 cm.	7.10 cm.	7.14 cm.
2	14.26 cm.	10.70 cm.	14.29 cm.	7.13 cm.
3	32.13 cm.	17.84 cm.	21.49 cm.	7.14 cm.
4	57.20 cm.	24.99 cm.	28.60 cm.	7.15 cm.
5	89.38 cm.	32.13 cm.	35.71 cm.	7.144 cm.
6	128.67 cm.	39.27 cm.	Mean	7.142 cm.

Ratios of these quantities to each other:

Ratio of S $S \propto T^2$	Ratio of S′ $S' \propto (T-1)$	Ratio of V $V \propto T$	Ratio of A $A =$ Constant
1.000	1.000	1.000	1.000
3.994	2.999	2.012	0.998
9.000	4.998	3.026	1.000
16.020	7.000	4.028	1.001
25.036	9.010	5.029	1.000

The value of the force of gravity is easily computed from the acceleration, the time of the pendulum being taken and the moment of inertia of the wheel being known. The latter is computed at the time of the construction of the wheel. The ribbons are weighed and masses of the counterpoise weights and the overweight found. Then by substitution in the formula below, the value of *g* is found.

$$g=\left(\frac{W+W'+\omega}{\omega \mid ^2}\right)a$$

W=mass of counterpoise weights, ribbon and clamp.
W′=the wheel constant for that particular machine.
a = the overweight.
a = the observed acceleration.

AN EXPERIMENT TO ILLUSTRATE CHEMICAL EQUILIBRIUM.

BY FELIX LENGFELD.
Professor of Chemistry, University of Chicago.

The subject of chemical equilibrium is of such fundamental importance that it should be taught the beginner as soon as possible. It is certainly less difficult to understand than much that one sees in every elementary text-book of chemistry. The student who has a working knowledge of the underlying ideas will find it useful in his later work, whether it be in chemistry or in subjects extremely remote from chemistry. A number of experiments illustrating chemical equilibrium have lately been collected by Noyes and Blanchard,* and deserve the careful attention of all teachers of the subject. To this list I desire to add the following experiment which, on account of its simplicity, is especially adapted to the needs of the secondary school:

Three explosion eudiometers (Hofmann's are best, but not essential) are connected so that the same series of sparks may be sent through all. In the first I put about 10 *cc.* of dry ammonia over mercury; in the second exactly twice as many *cc.* of a mixture of three volumes hydrogen and one volume nitrogen, also over mercury; and in the third some of the same mixture of nitrogen and hydrogen over dilute sulphuric acid. Sparks are now passed and in the course of a few hours the volume of gas in the first two is the same, showing that whatever be the initial stage, the final is identical. In the third eudiometer the liquid will rise to the platinum ears, showing that as fast as ammonia is absorbed, more is formed, and that the action is complete, because there is a tendency to a state of equilibrium, and not in spite of this tendency. As the experiment with the quantities given takes several hours, it is best to begin it one day and show the results the next, or to diminish the volumes taken.

*Jour. Am. Chem. Soc., XXII., 726 (1901).

RECENT ADVANCES IN THE PHYSICS OF WATER.

BY GEORGE FLOWERS STRADLING, PH. D.

For a long time it has been known that the most common of all liquids possesses physical properties which vary widely from those of other liquids. The large quantity of heat required to melt a gram of ice, the still larger quantity required to convert a gram of water into vapor at the same temperature, and the existence of a temperature of maximum density at 4° C, show that water is exceptional. It is not enough to know every anomaly; an explanation is demanded, which not only will enable us to see why water acts in a manner so different from other liquids, but also will explain its actions quantitatively.

In 1891, Röntgen* essayed a qualitative explanation. He takes water to be an aggregate of molecules of two kinds, which he designates ice molecules and molecules of the second kind. Common water is regarded as a saturated solution of ice molecules in a mass of molecules of the second kind. By the addition of heat, ice molecules are converted into those of the second kind. This is accompanied by a diminution of volume.

THE MAXIMUM DENSITY OF WATER.

At 4° C. water is at its maximum density. The addition of heat to a mixture of the two kinds of molecules will cause,—

1. A diminution of volume due to the change of ice molecules into the other kind.

2. An increase of volume, due to the expansion of the mass of molecules of the second kind.

The observed change in the volume of water is the difference between these two effects. When heat is applied to water at 0° C. a relatively large number of ice molecules are changed into those of the second kind, and the diminution of volume is greater than the increase. As the temperature rises, the number of ice molecules diminishes, and, hence, the farther addition of heat is not followed by as great a contraction of volume as at a lower temperature. At 4° C. the two opposite effects upon the volume are equal, while above that temperature the increase of volume is the greater.

*Wied. Ann., XLV., 90.

Röntgen gives this explanation of maximum density, but attributes it to another originator.

PRESSURE RELATIONS OF WATER.

He further assumes that an increase of pressure upon a mass of water kept at constant temperature results in some of the ice molecules changing into molecules of the second kind, and that the number so changing is greater, as the total number of ice molecules present is greater. This transformation causes a diminution of volume, which is greater, for a given pressure, at low temperatures, because then water is richer in ice molecules. Hence, when pressure acts on a mass of water the resulting change of volume is made up of—

1. A diminution of volume, due to the change of ice molecules into the second kind.

2. A diminution, due to the compression of the mass of molecules of the second kind.

The first of these effects will grow smaller as the temperature rises, because, with rising temperature, the number of ice molecules becomes less. The second will probably grow larger as the temperature goes up; at least, this is how liquids usually act. From the opposition of the effects of temperature, it can be seen that there might be some temperature at which the compressibility of water is at a minimum. According to the results of S. Pagliani and G. Vicentini* there is such a temperature at 63° C.

It is also found that the coefficient of thermal expansion of water, at least through a considerable range of temperature, increases as the pressure rises. With ether, carbon bisulphide and alcohol, the opposite is true. To find the explanation of this, consider the effect of an increase of pressure upon each of the volume changes considered under the heading "The Maximum Density of Water." The first, the diminution of volume, will be rendered less important by an increase of pressure, because by pressure the number of ice molecules is diminished, so that fewer are left to be changed by heat. Röntgen had no data from which to determine how pressure would affect the second. He thought it probable that there would be but little change. In that case, with rising pressure, the contraction of volume grows less and less,

*Beiblätter, VIII., 794.

while the normal expansion of the molecules of the second kind is unchanged, and the observed expansion of water, which is the difference of the two effects, should increase, as indeed it does.

Since, then, the unusual variation of the coefficient of thermal expansion of water with pressure is ascribed to the presence of ice molecules, it would be expected that the fewer of them there are, the less the irregularity would come in evidence. Hence, water at a high temperature or under a high pressure should manifest the variation to a less degree than at low temperatures or under low pressure. Amagat found that this is true.

He also found that the temperature of maximum density of water is lowered by pressure. According to the explanation already given of the existence of such a temperature, it is due to the presence of ice molecules. Could sufficient pressure be put upon water at 0° C. to cause all the ice molecules to disappear, probably there would be an uninterrupted expansion of volume as the temperature rose to the boiling point. We have seen that at 4° C. the effect upon the volume caused by an infinitesimal increase of temperature is zero, because the two opposing volume changes just balance each other. An increase of pressure lessens the number of the ice molecules and consequently gives to the expansion of the molecules of the second kind the preponderance. Under this increased pressure the balancing of the opposite effects no longer takes place at 4° C., but at some lower temperature, where the number of ice molecules is greater.

By pressure water can be cooled below 0° C. without freezing, because pressure prevents the formation of ice molecules.

VISCOSITY OF WATER.

Water under high pressure is less viscous than at atmospheric pressure. Generally its viscosity is made greater by dissolving other substances in it, and the larger the quantity of the solute the greater the viscosity. Its viscosity would accordingly be expected to increase with the number of ice molecules present. An increase of pressure by diminishing their number likewise diminishes the viscosity. An increase of temperature also acts to lower the viscosity by reducing the proportion of ice molecules, and very likely also by reducing the viscosity of the mass of molecules of the second kind as well.

(*To be continued.*)

Metrology.*

THE CENTENARY OF THE METRIC SYSTEM.

BY JACQUES BOYER, in *Revue Encyclopedique Larousse.*

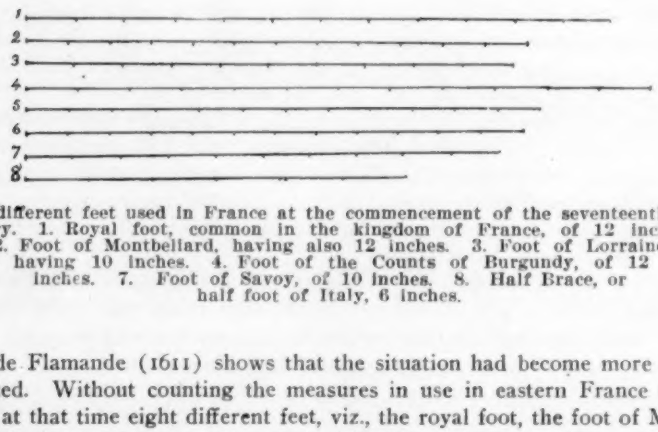
Translated by DR. WILLIAM H. SEAMAN.

The French government, preoccupied with the political questions of the day, has forgotten to celebrate the centennial anniversary of the Meter. Nevertheless it is one of the most important events of the last century and one that sheds honor on our country. The Academy of Sciences should naturally lead off, but it has not moved, notwithstanding the metric system has become of immense importance. Its founders hoped to accomplish one of the most gigantic reforms ever proposed, namely, to unify the innumerable measures of the nations. This object has not yet been completely attained, because of popular inertia, routine, national self-love, and especially because governments, in place of listening to the counsels of their wisest men and overcoming the obstacles ignorance puts in their way, prefer to remain in *statu quo,* the condition so dear to mediocrity. At this time, however, the meter is naturalized among all civilized nations. This result no longer appears only one of those Utopian dreams of the human race whose execution offers insurmountable obstacles, and the history of its realization, little known, is worthy of some notice. Fortunately, there is no need of an official celebration to bring to our minds the salient points of this history.

First we will recall some of the earlier attempts at unification of the French measures prior to the advent of the metric system. The origin of our ancient measures is too remote to be known with precision. Every locality adopted those apparently suitable to its condition, which explains their great variety. Later, as commerce increased, reflecting minds began to perceive the inconvenience of this diversity, but made little effort to remedy it. In France, during the first two dynasties of our kings, the measures were as far as possible from uniformity. The *modius* for example, the measure of capacity, was different in every province and sometimes in adjacent towns. Charlemagne was the first to decree, by the famous capitularies of Aix in 789, that the same measures should be used throughout his kingdom. His successors, Louis the Debonnaire and Charles the Bald, renewed his commands, and the last by the edict of

*Communications for the Department of Metrology should be sent to Rufus P. Williams, Cambridge, Mass.

Pistes, in 864, ordained that the measures in use should strictly conform to the models in his palace. But the records show those rules were little obeyed, because the laws of feudalism established that the right of sealing weights and measures belonged to the feudal lords, and since this tax was an important source of revenue, it was to their interest to maintain standards different from those of their neighbors. Hence a confusion began again which Philippe the Fair tried to prevent; but his barons had peculiar ideas on the subject of honesty and they continued their lucrative business without shame, even including debasement of the coinage. Philippe the Tall took a step in advance, declaring that not only should there be only one coinage of good weight struck by him, but he ordered that in place of the diverse weights and measures in use to the injury of many people, there should be throughout the kingdom but one single, suitable weight and measure for the people to use hereafter. But he encountered the opposition of the Tiers État, who by the vote of its deputies assembled at Orleans, October 10, 1321, rejected this reform. Francis I. (1510) and Henry III. (1575) were not more successful in their efforts, and the figure here given from the Mathematics and Geometry of the engineer



The different feet used in France at the commencement of the seventeenth century. 1. Royal foot, common in the kingdom of France, of 12 inches. 2. Foot of Montbeliard, having also 12 inches. 3. Foot of Lorraine, having 10 inches. 4. Foot of the Counts of Burgundy, of 12 inches. 7. Foot of Savoy, of 10 inches. 8. Half Brace, or half foot of Italy, 6 inches.

Claude Flamande (1611) shows that the situation had become more complicated. Without counting the measures in use in eastern France there were at that time eight different feet, viz., the royal foot, the foot of Montbéliard, that of Lorraine, Burgundy, Chastelet, Germany, Savoy, and the half foot of Italy.

In the middle of the 17th century the Abbe Gabriel Mouton, born at Lyons, 1618, tried to find a standard of length, and in his *Observationes Diametrorum Solis et Lunae Apparentium* (1670), he proposed to take as a fundamental unit a minute of a degree of the meridian. To this measure he gave the name of *mille*, and divided it decimally into *centuria, decuria, virga, virgula, decima, centesima,* and *millesima.* But he died in 1694 without having seen his proposition put into practice.

Another contemporary, Jean Picard, professor of astronomy in the College of France, measured with considerable precision by means of his improved instruments, an arc of the meridian between Sourdon, near Amiens, and Malvoisine, a village south of Paris. He found 57,060 toises, a result lacking only 14 toises of being correct. But he did something remarkable for that age,—he showed how to compare the measures he used with the length of a pendulum beating seconds at Paris. "If," said he, "this iron toise* (selected by the Academy of Sciences) shall perish like so many of the ancient measures of which nothing remains but the name, we will compare it with an original measure founded in nature itself which shall be invariable and universal." Here was the scientific principle on which the metric system rests. But little was required to arrive at a definite conception of the meter, only a more exact knowledge of the figure of the earth, and more perfect geodetic methods. The physicists of the XVIIIth century, among them Cassini, undertook the work.

By direction of the Academy of Sciences, Bouguer, Godin and La Condamine went to Peru in 1731 to measure anew an arc of the meridian, and another commission under the same distinguished direction went towards the North pole under the care of Maupertuis. It was thought that

MAUPERTUIS (1698-1759).
Facsimile of an engraving by J. Daulle.

*This was the iron toise made at the Grands Chastelet at Paris, by direction of the Academy of Science.

the flattening of the earth's figure at the poles might be determined by a comparison of the two measures. It is unprofitable to discuss the results of these two expeditions which were superseded by that of Delambre and Méchain. We will now consider the establishment of the metric system.

On the 8th of May, 1790, Talleyrand induced the National Assembly to

Prince TALLEYRAND (1754-1838).
From an engraving by Gerard.

adopt a decree paving the way for uniformity of weights and measures. This decree concluded by naming a commission composed of Borda, Lagrange, Laplace, Monge and Condorcet. They rendered a remarkable report on March 19th, 1791, pointing out what they considered the three possible bases of a rational system, viz.: First, a pendulum beating seconds; second, a quadrant of the equator; and third, an arc of the meridian. They eliminated the first because it introduced the element of time, and the second because of the difficulties attending its determination, and selected the third because it was capable of accurate measurement.

The Institute adopted this view and by the law of March 30, 1791, sanctioned the selection "of a unit that had no relation to any particular

L O I

Relative au moyen d'établir une uniformité de Poids & Mesures

Donnée à Paris, le 30 Mars 1791

LOUIS, par la grâce de Dieu, & par la Loi constitutionnelle de l'État, ROI DES FRANÇOIS: A tous présens & à venir; SALUT.

L'ASSEMBLÉE NATIONALE a décrété, & Nous voulons & ordonnons ce qui suit:

DÉCRET DE L'ASSEMBLÉE NATIONALE, du 26 Mars 1791.

Title of the law establishing the Metric System. From a poster of the time.

people or place on the entire globe." The base of this system was to be the length of one-quarter of a terrestrial meridian, and the measurements necessary to determine this base by measuring an arc of the meridian between Dunkirk and Barcelona were ordered to be made.

The Academy immediately named the members of the different committees who were to execute various portions of the work, especially to fix the unit of length and the unit of weight. The principal task was given to Delambre and Méchain and in the summer of 1792 they began operations. We need not recount the technical and political difficulties they conquered. Suffice it to say they gave the value of 5,130,738.62 toises to the arc, and before they finished their work it was decided that one ten-millionth of this fundamental unit should be the practical unit of

length from which all others were to be derived. The National Assembly, on the motion of Prieur, a deputy from the Côte d'Or, prescribed a provisional standard, based on the old calculations of Lacaille. It received the name of *Meter,* and the nomenclature of the metric system was fixed, after eighteen months of discussion, by the law of April 7, 1795. While the two astronomers worked in Spain and in France, Paris was not wholly idle. Lefèbre-Gineau calculated the relations of the kilogram with the customary weights in use by a series of observations whose accuracy excites today the admiration of experts.

When the geodetic labors of Delambre and Méchain were complete the French government invited all civilized nations to take part in fixing definitely the length of the meter. The International Commission which met at Paris consisted of representatives from France, Spain, Savoy, Tuscany and Denmark, the Batavian, Cisalpine, Helvetian, Ligurian and Roman republics. Among the delegates who took an active part in the deliberations of the congress, the Swiss Trallès and Van Swinden of Holland may be noted.

(*to be continued.*)

NOTES.

Spread of Metric Usage. The Bausch & Lomb Optical Co., of Rochester, have recently issued a catalogue of chemicals and reagents in which they use exclusively metric weights and measures. E. R. Squibb & Sons, Brooklyn, have been, up to this time, the only dealers to employ this system. If teachers, in ordering supplies, would write ***grams*** and ***liters*** instead of ***pounds*** and ***pints,*** other dealers would soon fall into line.

Metric Measures at the Pan-American. Near the main entrance of the Government building, on the Exposition grounds in Buffalo, stands a case containing the standard weights and measures of the United States, the metric being placed side by side with the English; for example, there is a copy of the latest meter bar of iridio-platinum, obtained from Paris in 1890, and the old Troughton brass bar sent over from England in 1814; a cylindrical liter measure of brass with the dry-quart measure and the liquid quart. A printed card explains that the liter is approximately one-twentieth greater than the liquid quart and one-tenth smaller than the dry quart. The troy and avoirdupois pounds are placed beside the half-kilo, the card stating that the half-kilo is one-tenth greater than the avoirdupois pound and two-tenths more than the troy pound. Various other weights and measures are conspicuously exhibited, the whole making an object lesson of rare value to show the simplicity and superiority of the metric system.

Notes.

BIOLOGICAL.

The Alimentary Canal of the Clam is very conveniently studied in a perpendicular longitudinal section through an alcoholic specimen, preferably of a flat species as of *Unio alatus*. Perpendicular transverse sections of another alcoholic specimen, at intervals of half an inch or so, floated in serial order in water and alcohol, show well the general structure.

State Normal School, Winona, Minn......................John M. Holzinger

The Mouth Parts of Insects are dissected out and carefully drawn by the students. Some of the dissections in a class of twenty students are so much better than others that they are worth preserving. This has been done here for several years with great satisfaction by mounting in glycerine jelly on ordinary microscopic slides under cover glasses. The dissecting microscope only is used. Of course, only the thinner organs are suitable for mounting. When not desired for a permanent mount the dissected material is kept on the glass slip in a few drops of glycerine until no longer needed for the comparison.

State Normal School, Winona, Minn......................John M. Holzinger

A Simple Way to Find Bacteria. In work in elementary physiology it has become imperative that the pupil should be familiarized with bacteria and their products. It is a lamentable fact that over 98 per cent of the teachers of physiology in our high-schools have had no training in bacteriological technique, and that over 90 per cent of them have never seen bacteria, outside of books. The difficulty of clearly seeing these organisms, when not stained, and the skill necessary to stain them, should make a simple way of demonstrating bacteria welcome. If tap water is allowed to stand for a few days, in an open vessel, a scum will generally form on its surface. This is especially true if the water contains organic matter, as flower stems, hay, meat, etc. This scum usually consists, for the most part, of bacteria. Prepare a perfectly clean slide. With a glass tube blow a bubble of air on the surface of the water. This bubble will generally last several seconds. Gently touch the slide to it. A very thin film of water will be left on the glass. As soon as this evaporates, the high power of the microscope will generally show bacteria, in large numbers, as minute dark bodies on a white background. I find this experiment excites more interest, on the part of the students, than the more complex ones with culture media and stains.

State Normal School, Winona, Minn......................W. H. Manwaring

Circulation of Blood in Frog's Foot. No doubt every physiology teacher has had difficulty with chloroformed frogs for showing circulation in web of the foot. The method of curarizing is not generally resorted to

by high-school teachers, and there is a simpler method which I have always found effective, namely, that of decapitation. The inexperienced teacher can do it more easily than he can destroy the brain with a needle. It is simply necessary to make one sharp clip with a stout pair of scissors through the region of the ear, and rolling the frog in a moist cloth, fasten two toes over a notch in a thin piece of board that will fit on the stage of the microscope. After the class had seen the circulation in the web of the foot, the frog may be opened and the beating heart demonstrated.

L. M.

Carbon Monoxide Ceases to be Poisonous when the animals breathing it are confined in oxygen under two atmospheres' pressure or air under ten atmospheres, even though 6 per cent. of carbon monoxide is present, while under ordinary pressures animals die when only 0.5 per cent. of the monoxide is present. If the animals confined in the vessel containing the mixture of oxygen and carbon monoxide be taken out into the free air, they die at once; but if the mixture is very slowly replaced by pure air, the animals survive exposure to the free air. The antidote then, for cases of poisoning by carbon monoxide, would seem to be the breathing of compressed oxygen.

Compt. rend. CXXXI, 483 .... A. Mosso

CHEMICAL.

Oxygen from Sodium Peroxide.—When small quantities of oxygen are wanted for certain demonstrations (as the endiometric determination of the composition of water, etc.), recourse is commonly had to a store of the gas in a gas holder, or potassium chlorate is heated in a small retort. Gas holders are, however, so bulky as to take up a good deal of room on the table, and the heating of potassium chlorate requires considerable attention to get a flow of gas at all uniform. The action of water on sodium peroxide gives oxygen, and its rapidity of flow may be quite easily regulated. The generator consists of a 300 to 400 c. c. Erlenmeyer flask fitted with a stop-cock funnel (see p. 89 of this Journal) and a delivery tube. The bottom of the flask is covered to the depth of about a centimeter with the peroxide, and the water allowed to drop on it just fast enough to keep up the evolution of the gas at the desired rate. The oxygen thus obtained is fairly dry, but to insure its perfect dryness a small calcium chloride tube can be readily attached to the delivery tube. Such an apparatus takes up but little room, can be put together in a very short time and requires but little attention to secure a pretty uniform flow of oxygen. For those who can afford the rather high-priced peroxide this method of preparation of oxygen is to be recommended for students' use also.

Metallic Sodium in Blowpipe Work. A small piece of metallic sodium, not more than three or four inches in diameter, is hammered out flat on

some smooth surface. The substance to be reduced is powdered and spread upon it, pressed into the metal with the hammer and the whole turned and kneaded into a little ball with a knife blade. It is then placed upon a slight depression in a piece of charcoal and ignited with a match or the Bunsen flame. A momentary flash ensues, and the reduction is accomplished. The residue is now heated before the blowpipe, and as the sodium oxide and hydroxide immediately sink into the charcoal any fusible metallic particles collect easily into a button and may be recognized in the usual manner. Volatile metals, like zinc, oxidize and yield with surprising readiness their characteristic coatings, and on digging up a little of the charcoal, moistening with water and placing upon a silver coin, the "Hepar" reaction is obtained if sulphur was present in any form. The metallic sodium does not need to be kept under naphtha, but may be supplied to a class in small rubber-stoppered, wide-mouthed bottles. A lump of sodium two or three centimeters in diameter will keep for months in this manner with only superficial oxidation. It must, of course, be carefully kept away from water or moisture. In rolling up the sodium and substance to be reduced into a ball, the metal should not be touched with the fingers, for with one or two of the more easily reduced oxides or sulphides the reaction sometimes begins spontaneously. This takes place quite readily with the peroxide of lead. Large quantities of sodium should be avoided or the reaction may become dangerously violent. From my experience in its use with classes during the last two years, I feel sure that sodium will soon be universally employed as a reagent in blowpipe laboratories.

Jour. Am. Chem. Soc. XXIII, 159 (1901) .... C. L. Parsons

Glass-Making by Electricity is being tried, and it is claimed that satisfactory results are being obtained. The materials in the form of fine powders are fed in the proper proportions into an electric furnace with several compartments, perfect fusion resulting in about twenty minutes. Fifty volts are sufficient with a suitable furnace and the current may be either direct or alternating. The advantages claimed are that the furnaces can be started or stopped in a short time, and that the expense of pots is saved.

Steam Metal is an alloy of copper (85 per cent), tin (7 per cent), zinc (5 per cent), and lead (3 per cent), and is used for making valves, cocks, etc. It is strong, but not brittle, not easily corroded, and can be worked at a high speed on the lathe. The addition of each ingredient, as well as its proportion, serves a special purpose. Thus, copper alone, while resisting corrosion, is too soft and tough, so that the tin is added to harden it. Such a binary alloy, however, does not make satisfactory castings, so that zinc has to be added. The lead serves to permit the alloy to be cut at a high speed.

Coke from Peat.—Successful experiments have been recently carried out in Sweden on the conversion of peat into coke. Peat with a calorific value of 2,500 heat units was made into coke with a value of 6,000 units. Similar experiments have been made in Russia, where there are immense peat deposits, and a large factory has recently been established. Not only is the coke produced very cheaply but valuable by-products are also obtained.

Platinized Porcelain is now being manufactured according to a process recently patented in Germany. The surface of the biscuit is covered with a certain preparation of platinum salts and the whole is then heated hot enough to fuse the coating. The porcelain is thus covered with a very thin but durable coherent film of platinum, which it is proposed to use in the manufacture of resistances, etc.

Test for Tin.—The blue color produced by the action of stannous chloride upon ammonium molybdate serves as a very delicate test for tin. After the usual separation the black flakes are filtered off, dissolved in hydrochloric acid and a few drops of this solution mixed with a little water and then some ammonium molybdate solution. A blue color shows the presence of tin.

Jour. Am. Chem. Soc., XXII., 220 (1901) .... ALLEN ROGERS

Test for Gold.—Solutions of gold salts when treated with hydrogen peroxide after the addition of caustic potash deposit in a few minutes, even in the cold, the gold as a black precipitate, which under the action of heat agglomerates and takes on a reddish brown color.

The reaction of peroxide of hydrogen in alkaline solution is much more sensitive qualitatively than any other reaction of gold. With 0.003 gram of gold per liter, a pale reddish coloration, appearing blue by reflected light, can be easily perceived.

Berl. Ber. XXXII., 1698 (1900) .... L VANINO and L. SEEMAN

Absolute alcohol may be prepared by the use of calcium carbide as a dehydrating agent. The powdered carbide is added to the alcohol until no more acetylene is given off; the alcohol then decanted and filtered from the residue. To remove the acetylene that may be dissolved in the alcohol the filtrate is thoroughly shaken with powdered mercurous nitrate, allowed to settle, the alcohol poured off and distilled. The product is perfectly free from odor.

The latest work on *Argon and Its Companions* confirms the previous statement that these gases are monatomic. Metargon is probably a myth, since experiments show that its spectrum is due to a carbon compound. The atomic weights, based on the latest data, are helium—4, neon—20, argon—40, krypton—80, xenon—128.

Recent work on *Selenium* shows that it exists in three distinct forms, the liquid (including vitreous, amorphous and soluble), the red crystalline and the gray crystalline (or metallic) form. Its specific gravity varies from 4.26 to 4.80.

Book Reviews.

A Reader in Physical Geography for Beginners. By RICHARD ELWOOD DODGE, Professor of Geography in Teachers' College, Columbia University. Longmans, Green & Co., New York. 13x19 ems., ix and 237 pages. $0.70.

This book is designed to be used in connection with a text-book and is for information rather than study; for suggestion rather than for daily class work. It is written in an interesting manner, smooth in style, by one thoroughly competent to deal with the subject. The book discusses the following topics: The continents, the industries of men, the origin of land forms, the great land forms, climate, and other physical features. To each of these topics several chapters are devoted; for example, under great land forms are described plains and plateaus, mountains, volcanoes and movements of the land.

The pictures are well selected, many of them being from photographs taken by the author, and each is accompanied by a short explanatory statement directing the reader's attention to what is most important in the picture. The maps also are explained in the same way. The parts devoted to the origin of land forms, and to great land forms, are particularly interesting and satisfactory. The references to local geographic features are frequent, and the explanation of drowned valleys, and how in the case of the Hudson, as explained on page 169, we prove that it is drowned, is very clear and instructive.

Prof. Dodge has produced a valuable and instructive book, which ought to be widely used as a supplementary reading book in older classes.

R. H. C.

Elements of Descriptive Astronomy. By HERBERT A. HOWE, A. M., Sc. D., Professor of Astronomy in the University of Denver. 14x21 cms., 340 pages. Silver, Burdette & Co., Boston. 1900. $1.40.

This book, intended to follow algebra and geometry in the secondary school, furnishes ample material for a year's work and affords some opportunity for intelligent selection by the teacher. As a rule the topics attempted are treated fully enough for the comprehension of the average

high school pupil, and in this respect this book is better suited to its purpose than most condensed editions of college text-books.

Observational methods of study are early introduced and are continued throughout the book to a reasonable degree. In the opening chapters the pupil is led through easy and interesting descriptive matter to the more difficult subject of celestial measurements.

Ingenious illustrations of celestial motions by similar effects within the experience of the pupil stamp the author as a resourceful teacher. Much encouragement in the use of models and drawings lends definiteness to the observational work, while numerous lists of suggestive questions stimulate the imagination in its application to infinite lines and surfaces.

Pertinent historical and literary allusions throughout the book, with numerous portraits of the pioneers in astronomical research, and a chapter on "Landmarks in the History of Astronomy," are unique features. A very detailed chapter on the constellations as a guide to their telescopic study, a fully annotated list of useful reference books and an attractive list of topics for essays are particularly suggestive to the teacher.

Numerous and excellent illustrations, some of which are colored, good print and paper and handsome binding give the book a mechanical excellence of the first order.

There can be no doubt that this attractive, readable astronomy will be welcomed by many students and teachers, either as a popular reference book or as a reliable high-school text-book.

Lake View High School, Chicago .... W. S. DAVIS

A Text-book of Astronomy. By GEORGE C. COMSTOCK, Director of the Washburn Observatory and Professor of Astronomy in the University of Wisconsin. 13x19 cms, viii and 391 pages. D. Appleton & Co., New York. 1901. $1.50.

While writers of current texts in elementary astronomy usually manifest a disposition to keep three or four classes of readers within their audiences, Professor Comstock apparently deems it wiser to "keep an eye single" to the needs of the student of astronomy. The emphasis of his thought is everywhere and obviously upon the *educative* value of the study, so that practical exercises and experiments with simple, inexpensive apparatus have found a prominent place throughout the book.

A large number of the illustrations are novel, ingenious and quite as worthy of close study as is the text. The writer has always found that some such simple devices as the one on page 7 for taking the sun's altitude, or the plumb-line apparatus described on page 13, together with such exercises as are given in connection with these and similar devices, will go farther to stimulate a boy's appreciative interest in astronomy and to awaken the true scientific spirit within him than will volumes of loose, popular and imaginative writing about the wonders of the heavens.

Another novel and distinctly commendable feature is the explanation

of the use of the eclipse map on page 112. No other astronomical subject attracts more interest among the laity than do eclipses. Whether this is because the frequent verifications of astronomical prediction afforded by eclipses arouses a greater respectability of credence in the popular mind than do the more occasional celestial phenomena, or because of the awe with which observed eclipses strike the unscientific mind, or for both or neither of these reasons, it would be difficult to say. It is certain, however, that there is a wholesome and widespread desire on the part of semi-scientific persons to learn how to use the data relating to eclipses of the American Ephemeris, *to which astronomers can afford to pander.* Moreover, it would seem more in accord with the purpose of a text-book for beginners to teach the methods of *using* eclipse data, than to expatiate upon the glories of an eclipse, or to present a fragmentary outline of the mathematical theory of eclipses, as is the wont of so many writers of elementary texts.

The rare instinct of the teacher is most conspicuously displayed in the rather copious use made of mathematical formulas. The idea seems to be to give the student a clear grasp of the underlying principles of both practice and theory, so far as unavoidable limitations will permit, without a desire either to eliminate or to lug in the mathematics of the subject. The idea that mathematical methods are intrinsically unlovely, or forbidding, to the student, we are glad to note, does not seem to have infected the author. When a principle can be more vigorously and readily seized by the aid of a formula, advantage is taken of it; but when the more direct route seems to lie through an experiment, or a sketch of the strategic outlines of an argument, the mathematics is omitted.

The employment of many cuts from photographs which contain the evidence for prevailing views, together with directions to the student as to the using of these cuts to verify the views for himself, will fan his latent scientific instincts and lead him to feel that astronomy is not a science of truth by authority of dogma; but that it is founded upon observation, classification and generalization quite as completely as are physics, botany, zoölogy and chemistry.

The writer would, however, criticise the statement beginning at the bottom of page 234 as misleading: "Instead of moving in orbits which are approximately parallel to the plane of the ecliptic, as do the satellites of the other planets, their (the satellites of Uranus') orbit planes are tipped up, etc., etc." The orbit planes of the satellites of Saturn can scarcely be regarded as "approximately parallel" to the plane of the ecliptic. No doubt this was an oversight and will be rectified in later editions of this book, which is certainly destined to run through several editions.

On the whole there is so much to commend in this book and so little to condemn either in purpose or execution, that the plainest statements of fact about it sound like fulsome praise. It is a presentation of the elements of the science along correct modern lines in such way as to be

admirably adapted to both the secondary schools and to the earlier years of the colleges and universities.

The publishers have added not a little to the value of the book in the way of excellent typography and artistic reproduction. Both in spirit and in form it is deserving of the appellation of a Twentieth Century Text-book.

G W. M.

Studies of Plant Life. A Series of Exercises for the Study of Plants. By HERMAN S. PEPOON, WALTER R. MITCHELL, FRED B. MAXWELL, Instructors in Biology in the Chicago High Schools. 13x18 cms., vi and 95 pages. D. C. Heath & Co., Boston. 1900. $0.50.

This little book contains two parts and an appendix. One would naturally expect Part I. to be made up of spore-plants and Part II. of seed-plants. Instead, Part I. deals with vegetative stages, reproductive stages, and life problems of types of all plants, divided into four groups: Thallophytes, 10 types; Bryophytes, 2 types; Pteridophytes, 3 typeh; Spermatophytes, 2 types—17 studies in all.

Part II. is more heterogeneous, being made up mostly of a more detailed study of seed-plants—a sort of organography. Renaming the studies of Spermatophytes as Group 5 must be an oversight.

There are seven studies: On seeds and seedlings; roots and their modifications; stems and their modifications; leaves and their modifications; flowers and some modifications; typical fruits, and an angiospum in flower,—each of these studies closing with "life problems."

The three divisions of the appendix are: "Experiments (22) and demonstrations to show the life phenomena of plants"; "A field trip for ecological studies"; and "The determination of one hundred seed-plants of Northeastern United States."

The field trip, of course, can be only suggestive, but the questions seem too difficult if the student is expected to work them out alone, as is indicated. But the set of questions is very helpful to those who wish to undertake field work and have had no experience in it.

Since the apparatus for any experiment may be of various kind and arrangement, it seems almost a waste of time for the student to draw it. Most of the experiments are prefaced with the conclusion that the pupil should draw, or the statement of what the experiment shows. It would be a great loss to the student, both in training and independence, not to draw his own conclusions.

To place the secretion of, CO_2 from roots, and the evolution of this gas from fermenting liquids, under "Respiration," if not a serious error, will certainly mislead the student. The experiment to show the place of growth in a root seems unreliable, since marking on the glass tube in which a root grows will not tell whether it grows one-half an inch or one-eighth of an inch from the tip.

L. M.

Books Received.

Chemical Lecture Experiments. By Francis Gano Benedict. The Macmillan Co., New York, 1901. xiii and 436 pages. $2.00.

Induction Coils, How to Make, Use, and Repair Them. By H. S. Norrie (Norman H. Schneider). Second Edition, Revised and much enlarged. Spon & Chamberlain, New York, 1901. xvi and 269 pages. $1.00.

A Hand-book for Teachers of Chemistry in Secondary Schools. By J. A. Giffin, B. A., LL. B., Collegiate Institute, St. Catherine's Ont. William Briggs, Toronto, 1901. vi and 75 pages. 60 cents.

Free-hand Perspective. By Victor T. Wilson. John Wiley & Sons, New York, 1900. xii and 257 pages. $2.00.

An Elementary Treatise on Qualitative Chemical Analysis. By J. F. Sellers. Ginn & Co., Boston, 1900. iv and 160 pages. 75 cents.

A Text-book of Commercial Geography. By Cyrus C. Adams. D. Appleton & Co., New York, 1901. xv and 505 pages. $1.30.

CLEARING HOUSE.

Teachers desiring to offer for exchange books, apparatus, etc., may insert a notice to that effect at the nominal rate of one cent per word, *in advance*.

WANTED—A complete set of the genuine Bock-Steger Anatomical Models; second-hand models in good condition will answer. Write at once to H. R. Hamilton, Oak Park, Ill., stating lowest cash price, delivered Chicago.

Reports of Meetings.

N. E. A. ROUND TABLE CONFERENCE IN BOTANY.

WEDNESDAY, JULY 10, 4:30 P. M.

L. Murbach, Detroit, *Chairman; Helen King,* E. Saginaw, Mich., *Secretary.*

The chairman opened the meeting by a short outline of the aims of the conference and suggestion of topics for discussion. He said, in part:

"The three factors in considering any school study are the boy, the teacher, and the subject. Of most practical value to those gathered here will be the subject. What kind of botany teaching will bring best results, whether for culture, for introduction to science, practical knowledge of plants, or the requirements of teaching? Many elementary text-books have been written, treating plants from different standpoints and in about as many different fashions as there are authors, though all agree on the

laboratory and field method as the best. Evolution of these books shows a slow transition from the systematic through the morphological to the physiological standpoint, at present laying great stress on ecology.

"Again, of the two phases of plant life, which is the more important? Summing up, then, we have for consideration:

"1. The importance of teaching botany by the laboratory and field method.

"2. Text-books.

"3. Relative importance of the study of germinations, seedlings; the adult plant—flowers, fruit and seeds.

"4. The amount of time to be given to observation, written work, and recitation.

"5. Can the high-school teacher make original contributions to science?

"6. Should colleges give credit for high-school botany?"

Dr. Pollock, of Ann Arbor, was called on, and discussed the first topic in an informal way. "It is still necessary to discuss the laboratory method. There is a need to combat the idea that all knowledge can come from books. Life in the city now has changed conditions, for children can correct their lack of natural surroundings by the study of sciences which will bring them knowledge first-hand. This work must be aided by the text-book. The supply of material is very simple and cheap." The speaker expressed himself as a believer in the teaching of morphology, for which study material is easy to obtain.

The chairman suggested that some plant identification might form a part of high-school work. Another speaker rose, asking the amount of plant analysis advisable. Mr. Murbach answered that the Detroit Central High-School took from three to ten plants.

In answer to a question about new text-books, the chair suggested Coulter's Plant Studies, Barnes' Outline of Plant Life, Bergen's Foundations, Atkinson's Elements, Bailey's Elementary Botany, and, for teachers, Ganong's Teaching Botanist. The question was asked, "How much time is taken for botany in Detroit?" The answer was, "Ten months, five recitations per week, two periods long."

Miss Elma Chandler, of Elgin, Ill., next read a paper on "Amount of Time to be Given to the Study of Germination; to Flower, Fruit, and Seed." "At least twice as much time, perhaps three times as much, should be devoted to these subjects, as to the whole subject of cryptogams, and to gymnosperms. The study of the gross anatomy of the seed and the organs of the seedling, accompanied by physiological experiments, should occupy about two-thirds as long a time as the study of the flower. This greater length of time should be given to the flower because of the unexcelled opportunity for training in observation of morphological features, offered by the manifold variations in flowers; for the sake of the training in thinking to be obtained from the study of ecological problems in connection with the subject of pollination. To the study of fruit and seed,

following upon the study of the flower, perhaps as much time might be given as to the study of the gross anatomy of the seed, made earlier in the course. Attention should be given chiefly to the origin of the various parts of the fruit, and to the adaptation for dissemination." The chair pointed out that much teaching of ecology has been done all along, but it has not received that formal title.

Topic 4 was not discussed, the speaker to whom it was intrusted not being present. Mr. Randall was called upon to discuss the subject, "Should universities give credit for high-school botany?" Mr. Randall being ill, it devolved upon the chair. It was said that the University of Michigan had given credit for valuable work done beyond the required work. The question arose, "What is the use of studying botany in the high-school if the student is to repeat the work in college?" One speaker said that credit is sometimes given for high-school botany at Cornell.

The chair then raised a point as to the study of flowerless plants, "Where should they be introduced in the course?" One speaker offered as a phase of this subject for discussion, "Is it possible for high-school pupils to be shown the development of sexual reproduction, through the asexual?" Experience was offered on this line by Miss Williamson; a valuable result of such teaching is, that pupils see the unity in nature. She had followed the suggestions of Prof. Bessey. Dr. Pollock asked Miss Williamson, "How much had the compound microscope been used?" Her answer was, "Some, with algae."

The last question brought up by the chair was, "Can the high-school teacher do original investigation?" Dr. Pollock said it depended upon three things—the teacher's time, the locality, the teacher's qualifications. If possible, it was advisable; it was valuable and helped the teacher to grow. The suggestion was also made that less routine work and more study and original work on the part of teachers would also be in the interest of students. The chair urged that teachers be encouraged to do at least statistical work, which could be used by scientists. Another speaker gave some helpful experience from the Mississippi valley, which showed the teachers that it is necessary to keep their eyes open. He and some other teachers had found some new facts and had communicated them to some scientist to whom they were of value.

In closing, Mr. Murbach called attention to the fact that the experiments in the biological exhibit were entirely set up by Detroit students, and that one of the chief things shown is, how much can be done by second year high-school students in improvising apparatus for plant physiology.

Reported by L. Murbach.

SCIENCE TEACHERS OF WISCONSIN NORMAL SCHOOLS.

On the 14th of June the science teachers of the seven Normal Schools of Wisconsin assembled at Madison in response to a call from State Superintendent Harvey to prepare more uniform courses of study in science than had hitherto existed in the schools.

The session continued for three days, and submitted courses in Physics, Chemistry, Zoölogy, Botany, Geology, Physiography, Geography, Physiology and Agriculture.

Noticeable in Supt. Harvey's address of instruction to the session was his disclaimer of any attempt to regulate the *order* in which the topics of any one science were to be taught, the *method* of instruction, or the *length of time* given to any topic. Consideration by the session was confined to the *topics* of each science, the relative amount of time given to class work and laboratory, suggested lists of experiments and necessary apparatus and a distinction between advanced and elementary *work as regards the Normal Schools.*

This is the first of a series of conferences instituted by Supt. Harvey, beginning with a general institute of all the Normal School faculties held at Oshkosh, Wis., the first of the year, and now to be continued in each department of instruction. If the first meeting of the science teachers is a prophecy of those to come, the plan will be of the greatest value, as it has facilitated, to a great degree, the understanding among the science teachers of the various schools of their duties and relations, and the very considerable fear of an attempt to hamper the individuality of the teachers by a rigid syllabus of work has been shown to be groundless.

Reported by E. C. Case.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The thirtieth meeting of the Association was held in Holyoke, Mass., Saturday, May 25. The members of the Association were the guests of Mr. J. T. Draper, of the Holyoke High School. The meeting was called to order by President Herbert J. Chase, and after the transaction of routine business the report of the standing committee on apparatus was read. The committee, through its chairman, Mr. C. H. Andrews, called attention to (1) a motor-rotator so made that the rotations may be either about a horizontal or vertical apis, a speed indicator indicating the actual number of revolutions; (2) an "all-aluminum balance," mounted on a glass base, enclosed in a glass case, having an eight-inch beam and sensitive to one milligram under a load of one hundred grams. The price of the rotator is $20.00 and of the balance is $15.00.

Copies of the Manual for 1901 were distributed. Mr. J. C. Packard reported progress in his effort to secure co-operation of similar associations in England.

The address of the meeting was given by Prof. Arthur L. Kimball, Ph. D., of Amherst College, on "Electro-Magnetic Waves and their Relation to Light." After discussing the development of the electro-magnetic theory of light up to the time of Maxwell, he said: "Maxwell was led to the conclusion that electric and electro-magnetic phenomena might be explained by the supposition of an electric medium capable of certain in-

ternal motions and possessing certain mechanical properties, and to avoid the unscientific process of thought of postulating two different ethers he was led to suppose that the medium on which electric effects and optical phenomena depend for their existence is one and the same." The speaker recalled the fact that the velocity of propagation of light and electro-magnetic phenomena have been shown by experiment to be the same. He then described the experiments by which Hertz established this generalization, and pointed out resemblances between the electro-magnetic and light waves, exhibiting by means of charts the mode of starting and the advance of electro-magnetic waves in the ether. In conclusion, Prof. Kimball mentioned the following books as suggestive reading on this subject: Fleming's Alternate Current Transformer, Vol. I., Chapter V., and Watson's Text-Book of Physics, Chapters XIX. and XX.

After lunch the members visited the Holyoke dam and headgate house, and were then taken to the flume, and there, through the courtesy of Engineer A. F. Sickman, shown the method of testing the practical and theoretical efficiency of the turbines, a wheel having been placed in position purposely for this demonstration.

Reported by LYMAN C. NEWELL.

Correspondence.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion, as well as answers to the questions of others. Those of sufficient merit and interest will be published.

DISCUSSION OF QUESTIONS.

22. *To what extent should a pupil doing laboratory work be thrown upon his own resources in the overcoming of any difficulties that may arise?*

The manipulation of apparatus is in a certain sense an art, and like other arts has usually to be learned through imitation and by practice. Any difficulties of manipulation should be foreseen by the instructor and the student taught how to surmount them. It is indeed true that an occasional failure in manipulation teaches much and that the pupil who is shown just how to do an experiment will not gain much power of originality in performing it. But it must be borne in mind that in the laboratory good habits must be learned. For one good way of carrying out a certain manipulation there are several poor ones, and the student is more than liable to find out for himself the poor ones. With constant attention and correction on the part of the teacher, however, the pupil will sooner or later acquire habits of manipulation that will make him less and less liable

to do things in a wrong way. He can then be thrown more and more upon his own resources, although he should always be made to feel that his manner of working is being closely supervised. C. E. L.

23. *Why is it that the students of the physical sciences do not usually know how to do the simplest algebraic work, even though they have had courses in algebra and geometry?*

24. *How can the poor mathematical work done by students of the physical sciences be improved?*

These questions came up incidentally in the Chemistry Round Table Conference of the National Educational Association at its meeting in Detroit, July 11, 1901. Abstracts of what was said at that time here follow:

Mr. E. H. Heacock, Topeka, Kas.—"My pupils are frightened by a proportion or a fraction in their study of chemistry. The fault does not seem to lie with the teachers of mathematics because the pupils *do* know their algebra and geometry. I do not know where the trouble lies."

Mr. Newman, Cincinnati.—"It can't be a case of having forgotten their mathematics, for pupils in my classes have been studying advanced algebra and geometry at the same time with their physics and chemistry; they certainly know enough of mathematics, but they don't seem to know how to apply it."

Mr. Courtois, Detroit.—"I find the following remedy effective. I give my classes a lesson on the mathematical questions involved."

Mr. B. W. Peet, Ypsilanti.—"The difficulty does not arise from the student's lack of knowledge of his mathematics. I require my students to make up standard solutions of alkalis, then, by titration, with known acids, to determine whether the alkali solution is exact. These same people are students in calculus and geometry, but the above mentioned problem always causes difficulty."

Mr. Frederick C. Adams, Providence, R. I.—"I should like to offer as a suggestion an expedient that has proved useful to me. My students substitute x, y, or z for the unknown quantity. This gives them familiar mathematical expressions. Now, further, it appears to me that in science, teachers have one of the rarest opportunities in the whole field of education. It is to bring into correlation the two subjects of science and mathematics."

Mr. C. W. Parsons, Evanston, Ill.—"I would go back to the mathematical texts and ask for better problems there; i. e., examples in science."

Mr. C. E. Linebarger, Chicago.—"The trouble with that would be that we would have to get a new set of mathematics teachers. The majority of those now teaching mathematics have neither sympathy nor knowledge of science. It would certainly be a most excellent thing, however, if it were possible to substitute some physical and chemical problems for the usual "John and James" and "apples and pears" ones to be found in our algebras. This is a matter that demands attention, and a campaign of education should be started."